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# Beam delivery and dosimetry of laser-driven particle beams

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Radiation therapy is an important modality in cancer treatment. Particle beams, due to their superior dose profile over photons, provide higher tumor dose conformity and healthy tissue sparing. But due to the high costs and huge size of the existing ion beam therapy (IBT) facilities, particle therapy is limited to few, large centers only. Ion acceleration on micro-m scale via high intensity laser has become a compelling alternative to conventional accelerators and gained interests for its potential to reduce size and costs for IBT facilities. Next generation petawatt lasers promise laser-driven particles (LDP) with therapeutic energies. But, in contrast to conventionally accelerated quasi-continuous mono-energetic pencil beams with about few Gy/sec dose rate, LDP beams have diverse properties, i.e. ultra-intense pico-sec bunches with about 1010 Gy/sec dose rate, large energy spread and divergence, and with only up to 10 Hz repetition rate. These properties make it challenging to adapt LDP beams directly for medical applications. In addition to laser particle accelerator development for generating therapeutically applicable beams, the distinct features of these beams demand new technical solutions for beam transport, field formation, dose delivery and dosimetry, along with research on the radiobiological consequences. The presented work is an ongoing joint translational research project, namely onCOOPtics, of several institutions in Germany aiming to establish laser-driven IBT. We will present the status focusing on beam delivery and dosimetry.
Laser-based technology for LDP beams has been established for cell and small animal irradiation using a fixed beamline based on permanent magnets and integrated dosimetry and cell irradiation system (IDOCIS), which is being utilized for systematic radiobiological studies. For the translation towards clinics, focusing on laser-driven protons and proton therapy systems, a highly compact 360° isocentric proton gantry system (about 3 times smaller than conventional proton gantries) has been designed based on light-weight iron-less high-field pulsed magnets. The gantry is integrated with beam control, energy selection and a novel dose delivery system, capable to magnetically control the beam spot size and to scan the beam for advanced irradiation schemes. A 3D TPS has been adapted for dosimetric evaluation of our system and high quality clinical treatment plans can be provided with such beams. For the gantry realization a pulsed 40 T solenoid for particle capture and a 10 T compact iron-less 50° sector magnet were successfully tested. A pulsed 120 T/m gradient quadrupole is being manufactured.
The conventional University Proton Therapy facility Dresden (UPTD, first patient treatment in Dec. 2014) is additionally equipped with a petawatt laser laboratory and an experimental bunker. This will allow testing for clinical applicability of LDP systems side-by-side with conventional therapeutic beams as reference.
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